

# Soil moisture forecasts based on the CFSv2 forecasts

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To improve the hydroclimate forecasts is one of the goals of the MAPP Drought Task force

# Objectives

Are CFSv2 forecasts add any skill to the soil moisture forecasts based on persistence or ESP?

- We compare
- A) Seasonal soil moisture forecasts directly from cfsv2 seasonal forecasts **vs** persistence
- B) ESP **vs** CFSv2\_vic forecasts by forcing the VIC using daily P, Turf and surface winds from the CFSv2 forecasts (CFSV2\_VIC)

# VIC(simulation)

## ➤ Purposes:

- (a) Initial conditions for CFSv2\_VIC run ;
- (b) Verification

## ➤ Model: VIC\_4.0.6 their current operational model

## ➤ Forcing: derived from observations

## ➤ Period : 1 Jan 1979 to Dec 2010

## ➤ Initial conditions 31Dec1978 from the UW simulation from 1916.

# Cross validation

➤ Forecast period 1982-2009

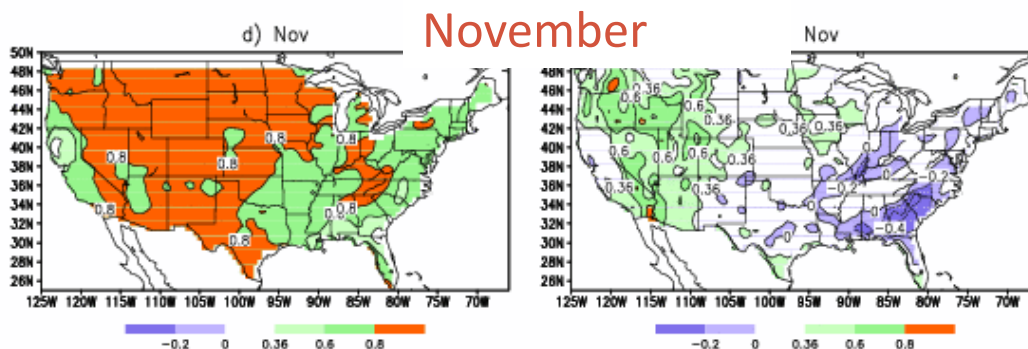
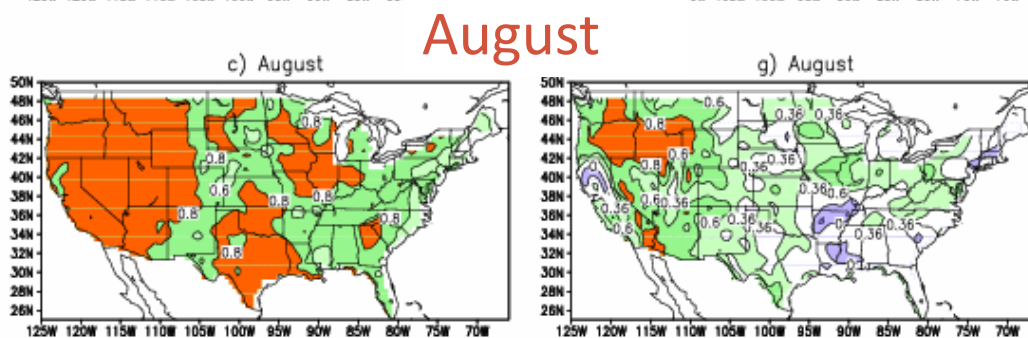
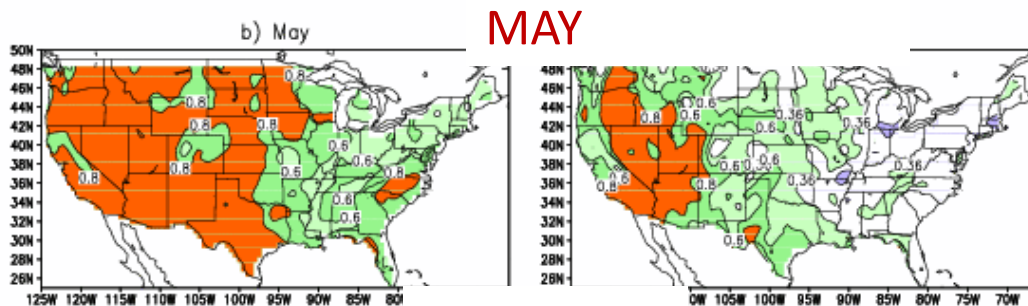
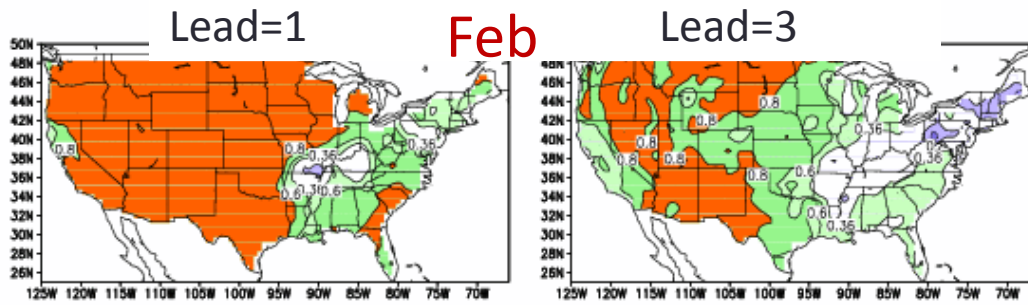
- BCSD Error correction for all SM fcsts (probability mapping, Wood et al 2005 )
- All parameters of the BCSD correction and anomalies were determined from data in the training period based on a VIC (simulation)
- After error correction, SM for the target month is verified against the corresponding SM anomalies from the VIC(sim)

# RMSE and Correlation

- RMSE— normalized by the standard deviation of the VIC(SIM)  $R > 1$  no skill
- R ratio
- $R(\text{exp1}/\text{exp2}) = \text{RMSE}(\text{exp1})/\text{RMSE}(\text{exp2})$
- If  $R < 0.8$ , then Exp1 is more skillful than Exp2
- If  $0.8 < R < 1.2$  They are comparable
- If  $R > 1.2$  Exp2 is more skillful than Exp 1

Shukla and Lettenmaier  
2011

# correlation for persistence

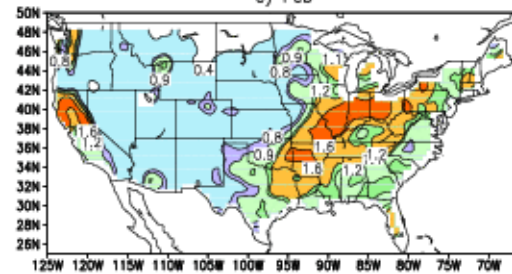
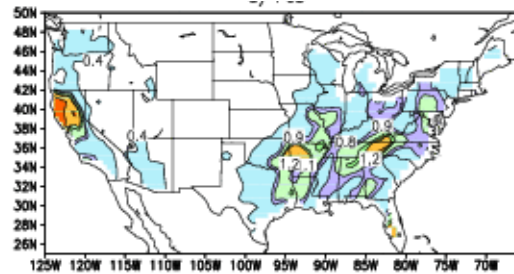


1. Forecast skill is seasonally and regionally dependent
2. At lead 1, forecasts based on persistence are statistically significant.
3. At lead 3, forecasts over the western interior region are significant
4. Skill is highest for Feb, and lowest for Nov.

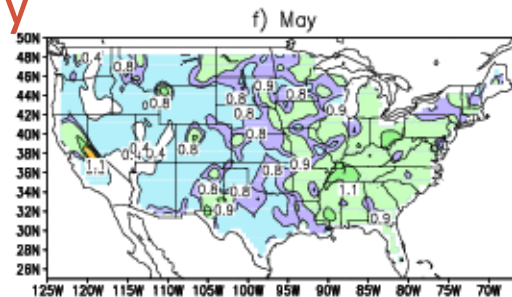
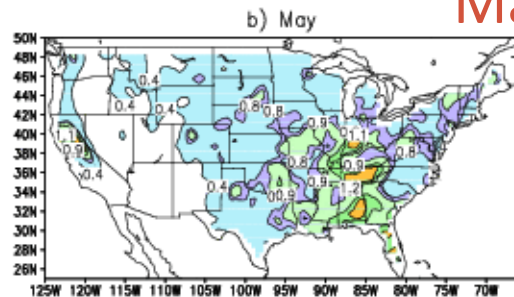
R lead=1

Feb

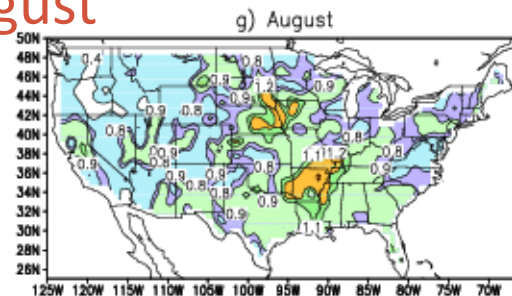
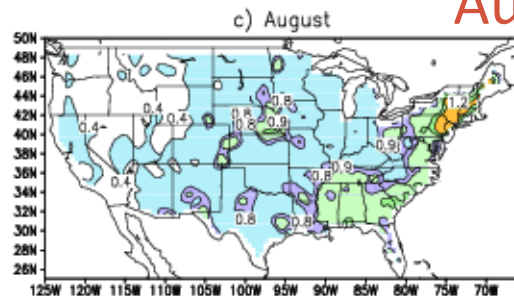
R lead=3



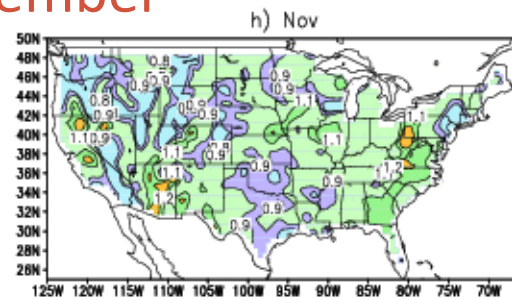
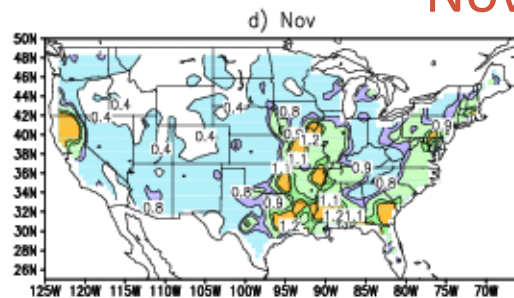
May



August



November



0.4 0.8 0.9 1.1 1.2 1.6

0.4 0.8 0.9 1.1 1.2 1.6

## R(persist/CFSv2)

1. If  $R < 1$  : persistence has higher skill (blue)

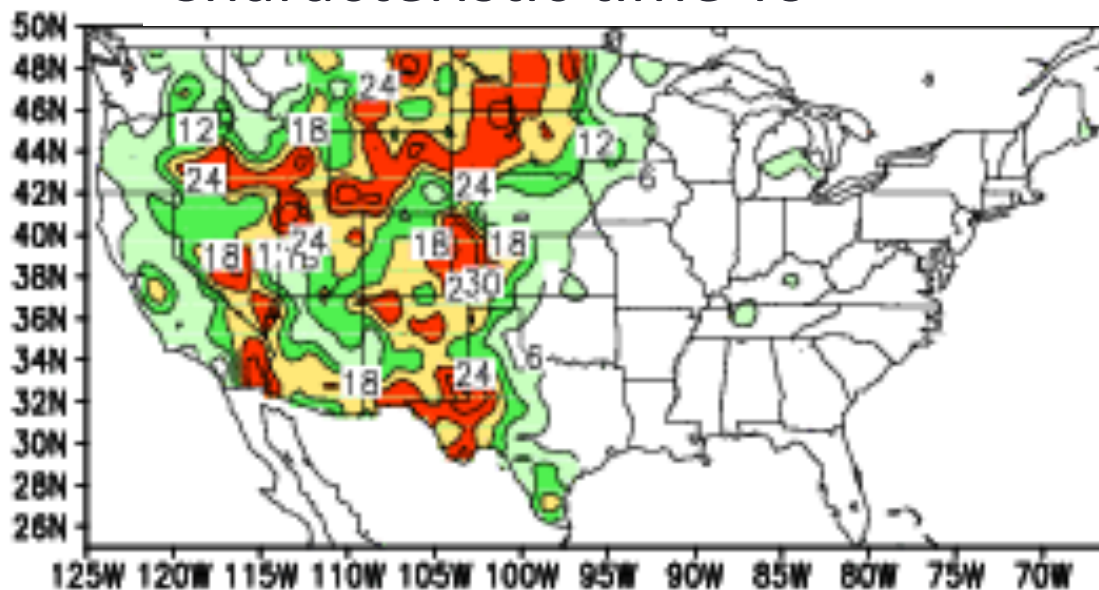
2. If  $R > 1$  CFSv2 has higher skill (red)

1. At lead 1, persistence dominants
2. At lead 3, for areas over the western region, persistence still has higher skill
3. The eastern region during Feb , CFSv2 has 'higher' skill, but the skill is too low to make any difference



# Reason that persistence does well

Characteristic time  $T_0$

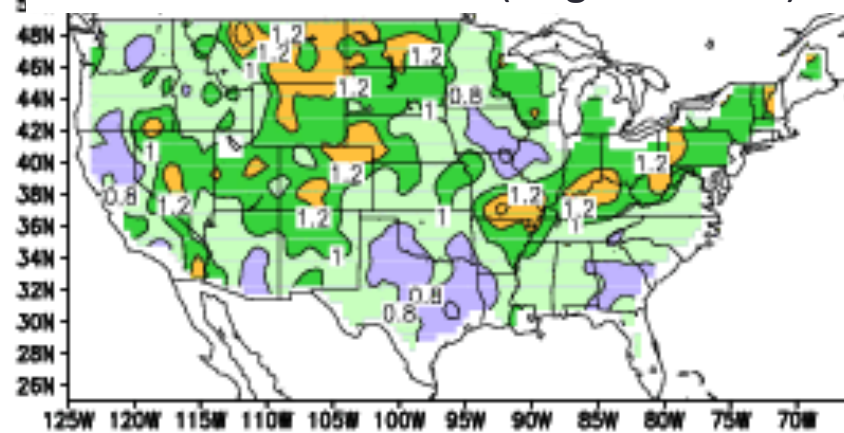


SM has high persistence  
over the western region=>  
high skill

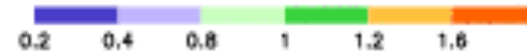
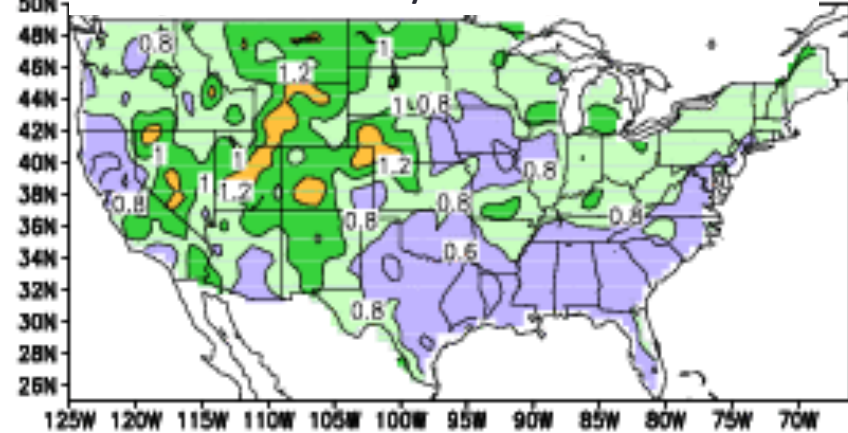


# Reason that CFSv2 does poorly

RMSE for CFSv2 lead=1 ( avg 4 seasons)

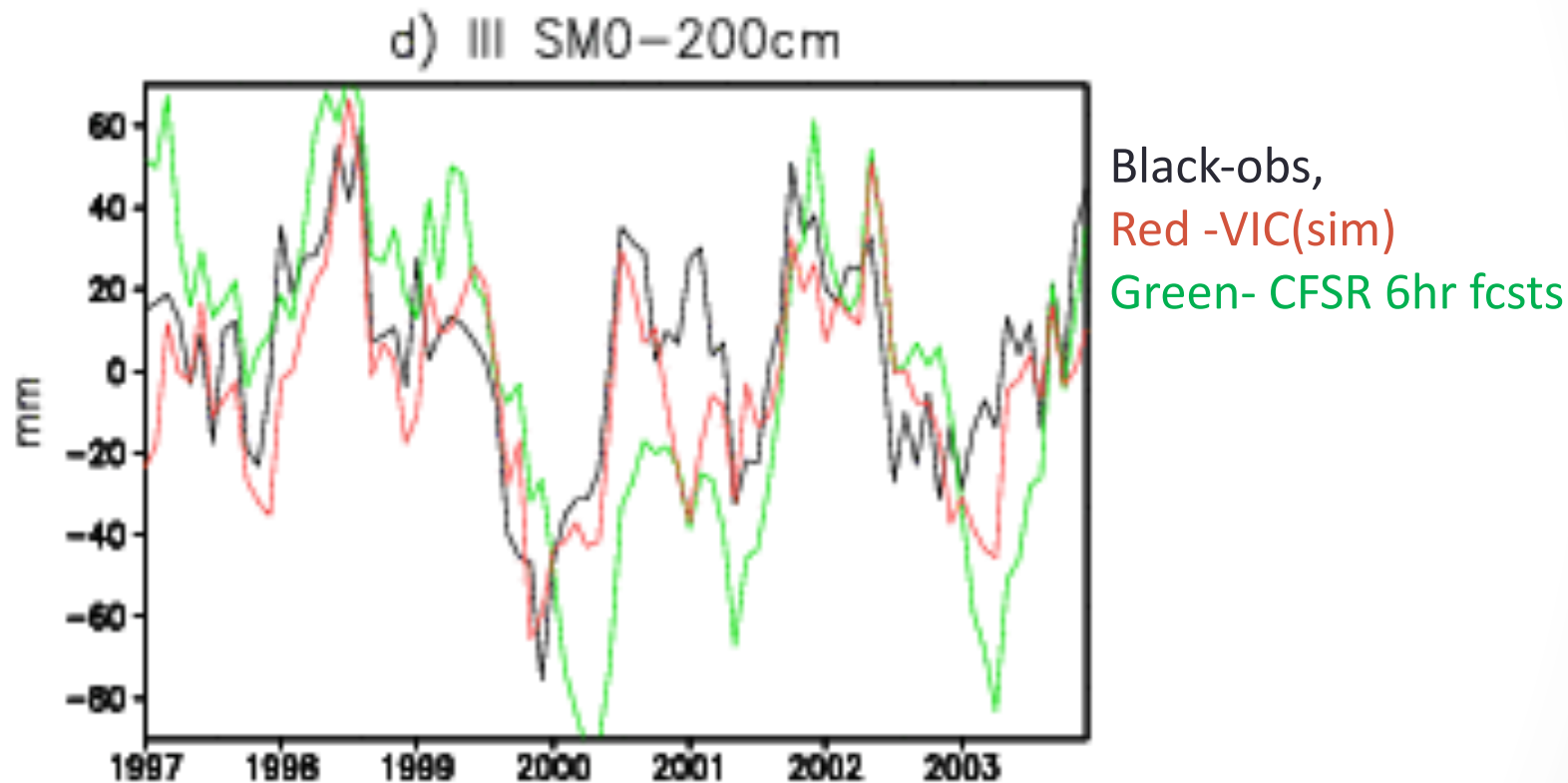


RMSE CFSR 6-hrly fcst lcs for CFSv2



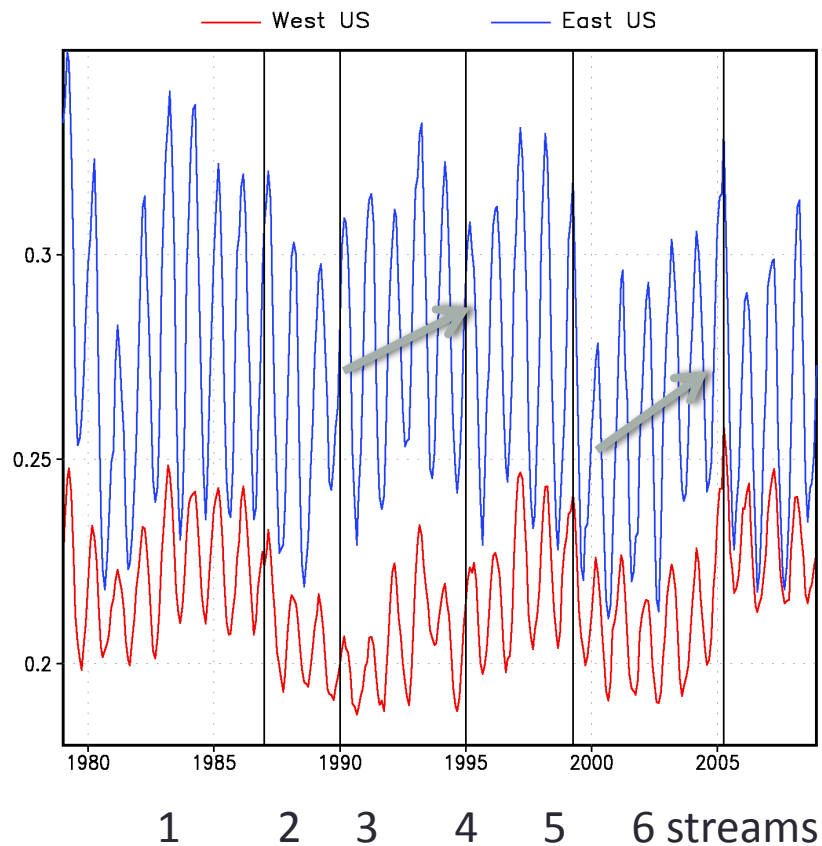
Low skill for CFSv2 is due to errors in the initial conditions taken from CFSR 6-hrly fcsts

# Verification against the soil moisture from the Ill water Survey



1. Comparing with SM observations from ILL. water survey indicates CFSR has large errors

# CFSR SM spin up



Volumetric total SM fraction  
Monthly mean for the  
West: (25-48N,97-125W)  
East: ( 25-48N, 45-97W)

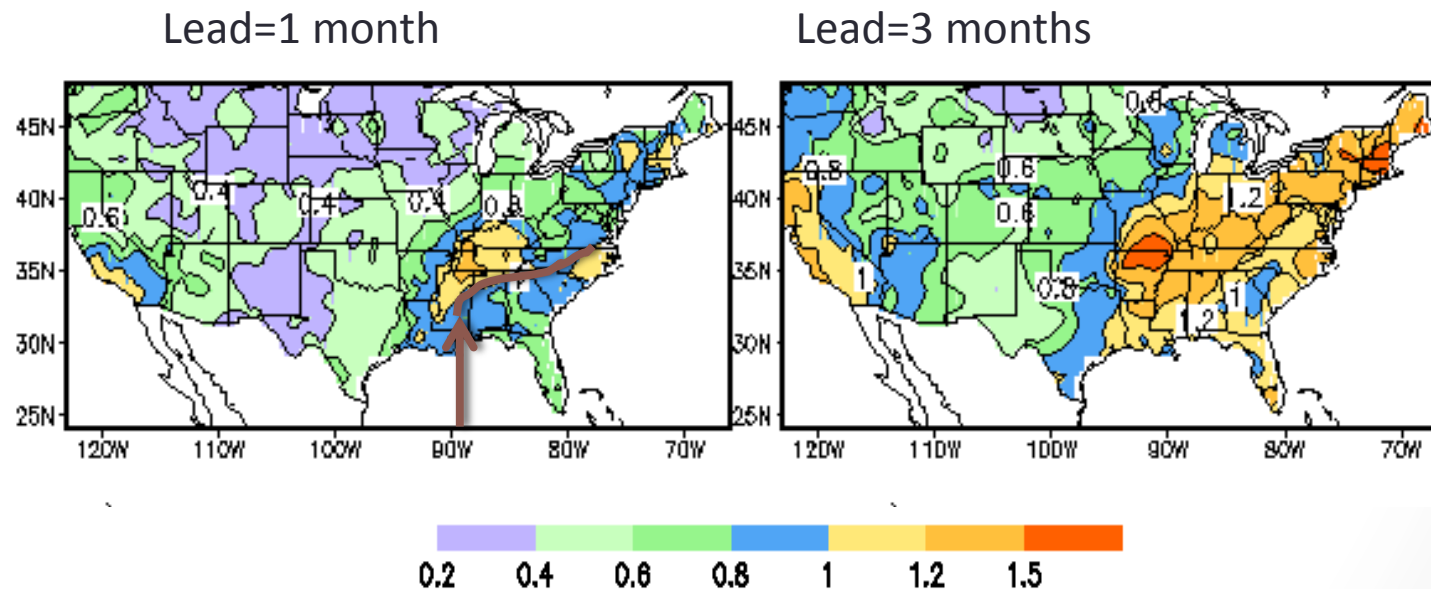
CFSR was run in  
6 streams. It has  
the SPIN UP  
problem

From Wanqiu Wang

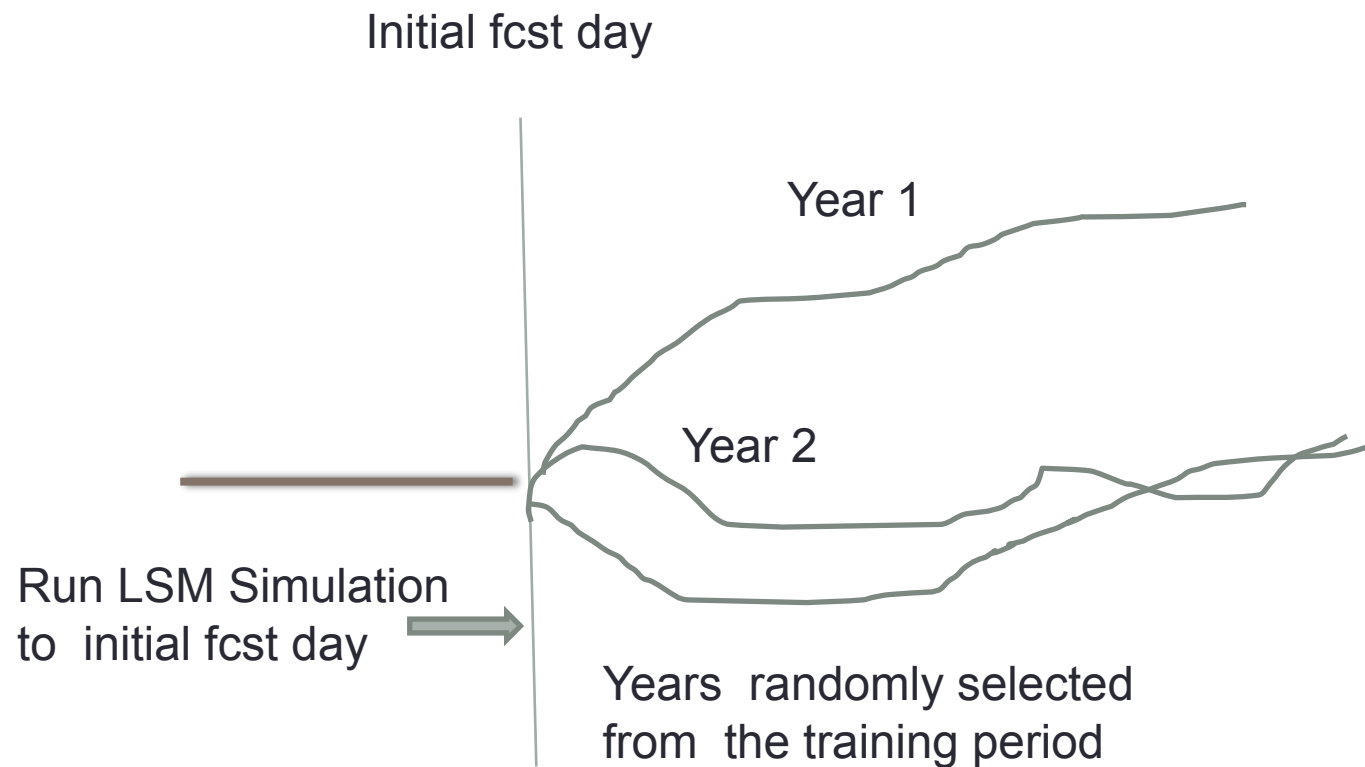
# Soil moisture prediction

- For the western interior region west of 95W or for lead=1 to 2 months :Persistence is a good forecast tool
- Lower skill over stormy region where dynamics is important

RMS errors for persistence Jan 1982-2009

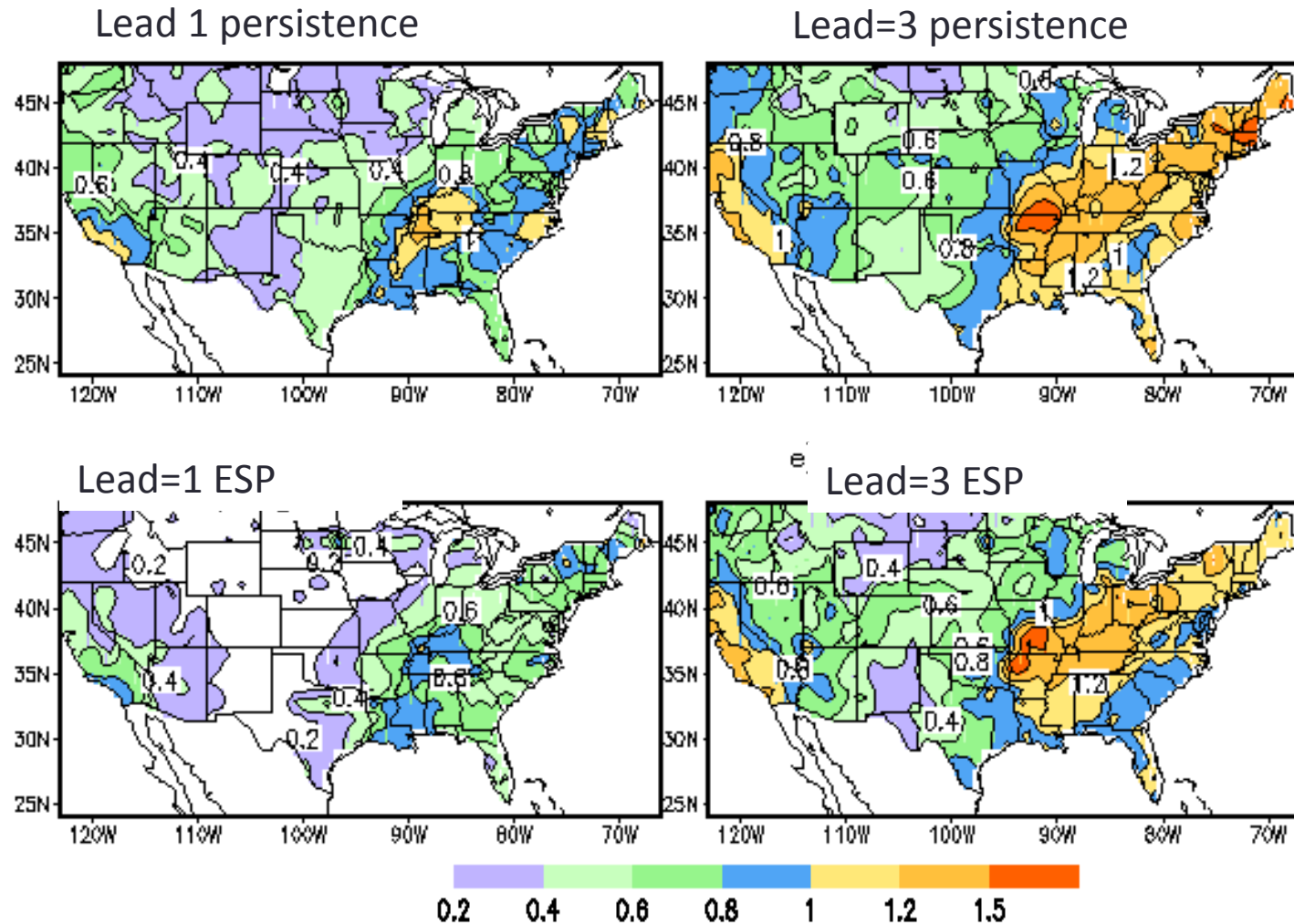


# Ensemble Streamflow Forecasts (ESP)



Daily P and Tsurf were randomly selected from the training period. They are used to derive forcing

# Ensemble streamflow prediction vs persistence (JAN)



- For all leads, ESP has higher skill than persistence.
- For SM and runoff fcsts, the initial conditions are extremely important for short leads on seasonal time scales

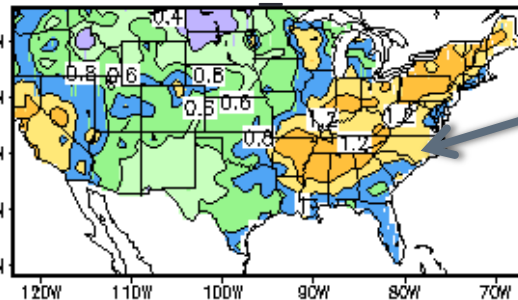
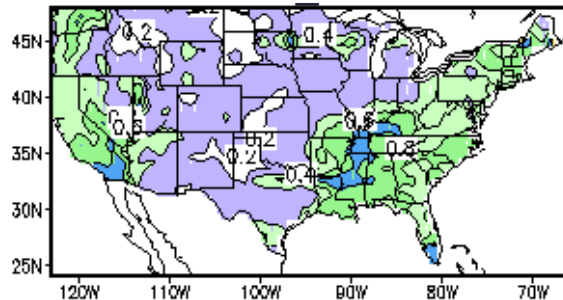
# Can CFSv2 forecasts help?

RMSE Lead=1

RMSE Lead=3

CFSv2 VIIC

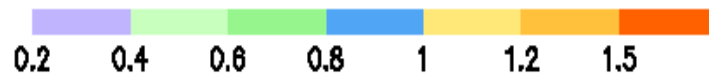
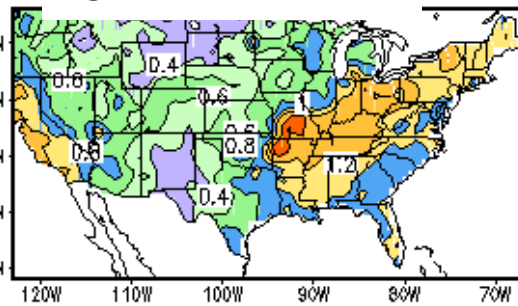
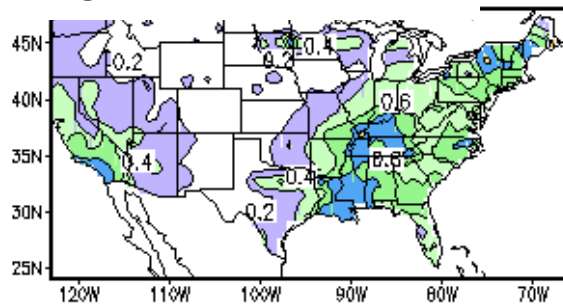
CFSv2 VIC



CFSv2\_VIC is better  
but skills are low

ESP

ESP

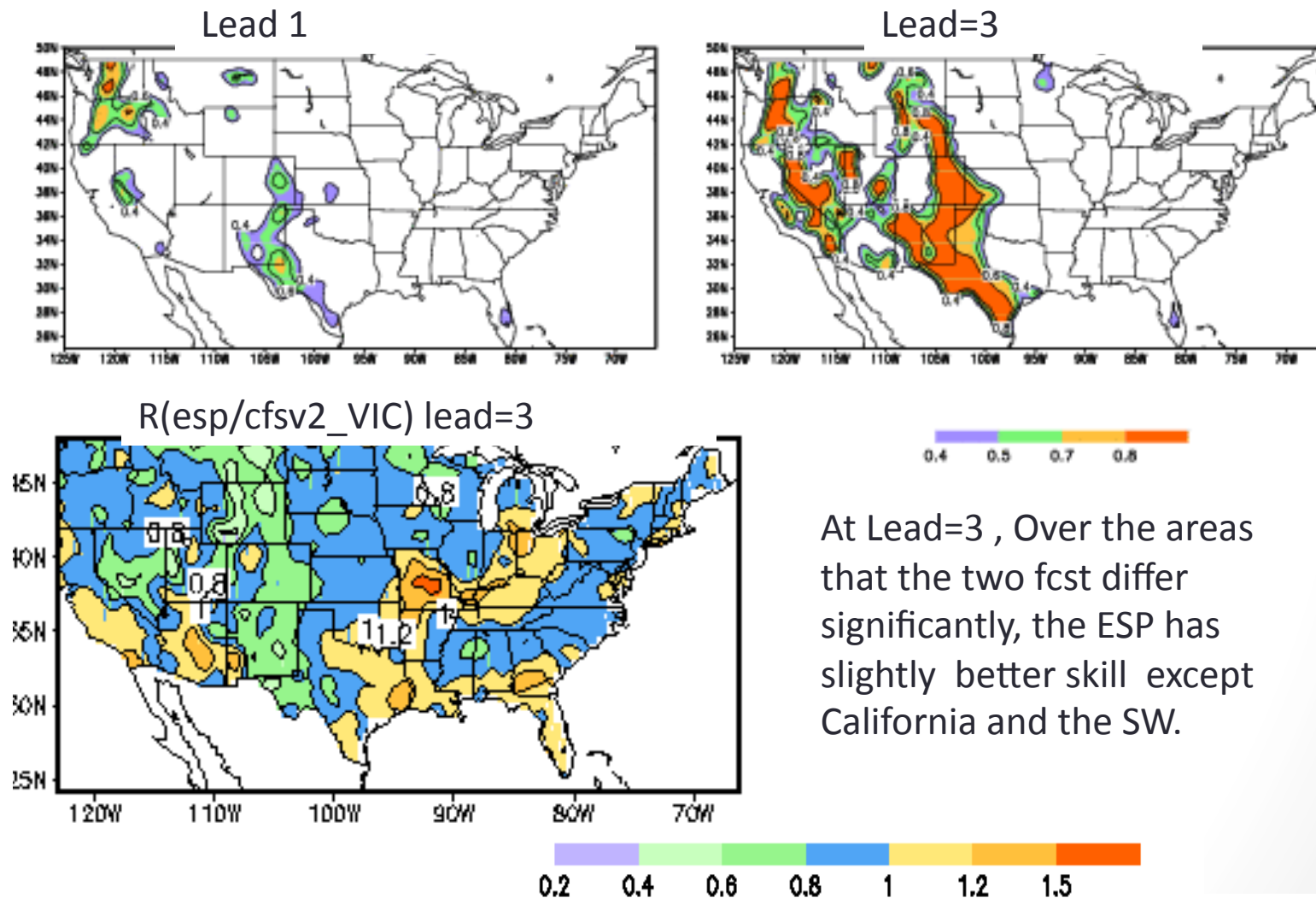


- Over the western interior region, the ESP has slightly higher skill.
- Over the Eastern US the stormy region and the west coast, knowing forecasts helps.



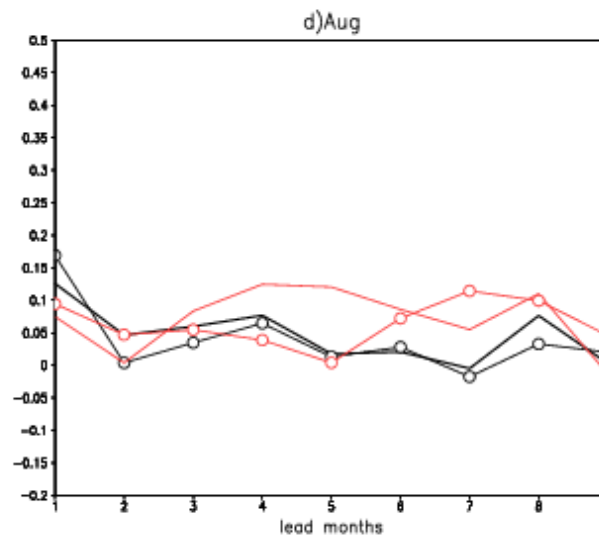
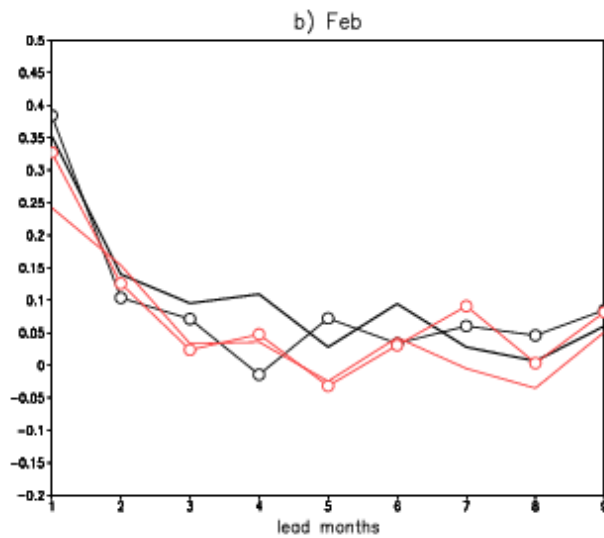
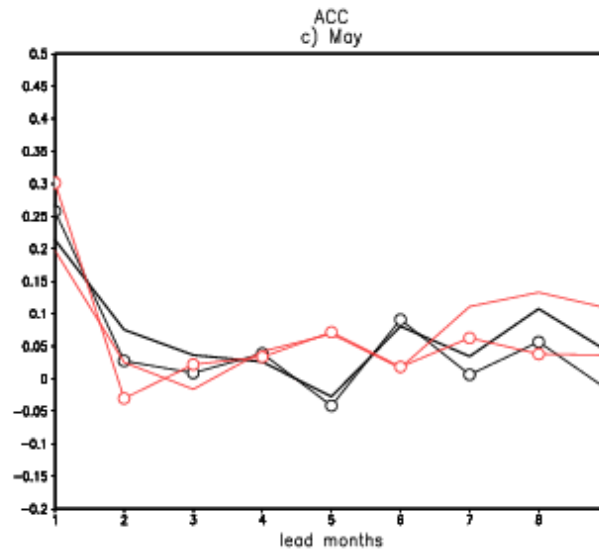
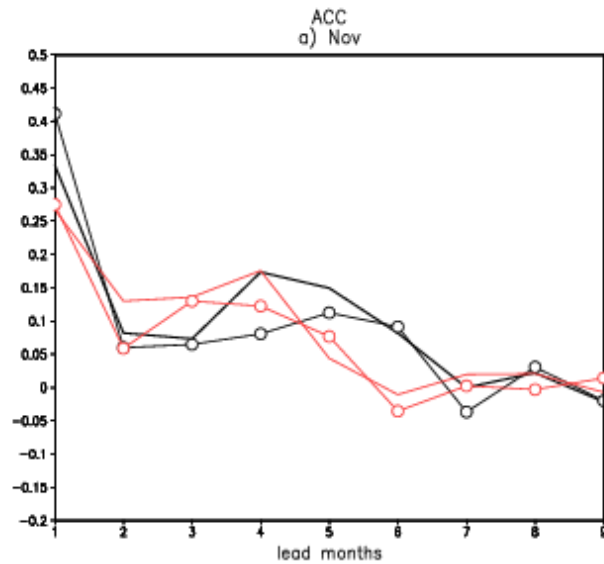
# CFSV2\_VIC & ESP : How different are they?

Taken into consideration of spread, the percentage of years, the differences between the CFSv2\_VIC and ESP are statistically significant at the 5% level



# ACC for CFSv2 monthly mean P

Better than Cfsv1, but after lead=1 skill is very low



— CFSv2

— CFSv1

With open circles: 8 members

No circles  
16 members

# Conclusions

For SM prediction, we need to have accurate initial conditions

- SM forecasts taken directly from CFSv2 have low skill than persistence at short lead time because of errors in the initial conditions.
- On seasonal time scales, ESP works nicely.
- There are no statistically significant differences between CFSv2 and ESP for lead=1 month. At Lead=3, differences are over the western region.
- For the CFSv2\_VIC forecasts to improve sm forecast skill, the CFSv2 forecasts need to be skillful for the long lead (> 2 months)

# Recommendations

- For SM forecasts, skill comes from the initial conditions for the short leads.=> **avoid spin-up problems**
- If the initial conditions are good, then the CFSv2 should give better forecasts because the model takes into account of the coupling between land-atmosphere
- Design of hindcasts– should cluster around the fcst day.

# Who are we?

- Lichuan Chen –University of Maryland CPC
- Thanks to the University of Washington  
Dr. Dennis Lettenmaier's group
- Shrad Shukla did the ESP forecasts

# CFSv2 and persistence

- **Persistence**— forecast for the target month  $M$  and lead  $t$  is the sum of the climatology for  $M+t-1$  and SM anomaly for month  $M-1$ . Anomalies are determined from data in the training period.

e.g Feb 1989 persistence fcst lead 1 = anomaly for Jan 1989 + Feb climatology

- **CFSv2 SM forecasts**: ensemble for 8 members of SM monthly mean forecasts taken directly from CFSv2. They were treated by the BCSD correction